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OSWER Directive Initiation Request

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2. Originator Information

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3. Title

Final RCRA Comprehensive Ground-Water Monitoring Evaluation (CME) Guidance Document

4. Summary of Directive *(include brief statement of purpose)*

The CME guidance document provides a framework for evaluating inspections/evaluations of groundwater monitoring systems under RCRA. The document contains text and a detailed checklist and draws heavily from the RCRA Ground water Monitoring Technical Enforcement Guidance Document (TEGD) and Compliance Order Guide (COG).

5. Keywords

CME, ground-water monitoring, TEGD, inspections, RCRA

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9. Name and Title of Approving Official	Date

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FINAL RCRA COMPREHENSIVE
GROUND-WATER MONITORING EVALUATION
GUIDANCE DOCUMENT

December 1986

FINAL COMPREHENSIVE GROUND-WATER MONITORING EVALUATION
GUIDANCE DOCUMENT

Introduction

Several types of inspections and evaluations have been developed by the United States Environmental Protection Agency to assist the Regions and States in determining the degree of compliance with the Resource Conservation and Recovery Act regulations of owners and operators of hazardous waste management facilities. These inspections/evaluations cover all aspects of the RCRA requirements for all types of facilities. They are performed by people of various backgrounds throughout the country. It is the purpose of this guidance to provide a framework within which inspections/evaluations may be performed, and to promote, therefore, a nationally consistent approach to that performance. Among the benefits are a clearer understanding among regulators and the regulated community of the scope of each inspection/evaluation, and the compilation of a reliable, reproducible data base. Site specific conditions will determine, within the scope, the extent of the evaluation at a particular site. A consistent approach to conducting inspections/evaluations removes a source of artificial variability, and so focuses more attention on the findings rather than the methods. Clearly, the findings of inspections/evaluations are integrally important to the enforcement process. The Compliance Monitoring and Enforcement Log (CMEL) lists ten categories of evaluations: Compliance Evaluation Inspection, Case Development Inspection, Comprehensive Ground-Water Monitoring Evaluation, Follow-Up Evaluation, Sampling Inspection, Citizen Complaint, Part B Call-In, Withdrawal Candidate, Closed Facility and Other-General. At this point in time, OWPE intends to develop guidance for three of them:

1. Compliance Evaluation Inspection (CEI) is an on-site evaluation of the compliance of a facility with RCRA regulations and permits intended to gather information necessary to support an enforcement action.

2. Case Development Inspection (CDI) is an intensive investigation intended to gather sufficient information to support an enforcement action.

3. Comprehensive Ground-Water Monitoring Evaluation (CME) is a detailed evaluation of the adequacy of the design and operation of ground-water monitoring systems at RCRA facilities.

Guidance for conducting Sampling Inspections will be integrated with CEI, CDI and CME guidance, and guidance for Follow-Up Evaluations will be part of CDI guidance.

This document is a detailed exploration of the scope of and methods for conducting a Comprehensive Ground-Water Monitoring Evaluation (CME). It is divided into two major parts, the text which explains in detail the scope and methods, and a checklist for use by the person conducting the evaluation. This document is supported by guidance on the other inspections/evaluations, the RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, the RCRA Ground-Water Monitoring Compliance Order Guide, and a health and safety manual.

Section I. Summary of Approach and Office Evaluation

The objective of a Comprehensive Ground-water Monitoring Evaluation (CME) is to determine whether an owner/operator has, in place, a ground-water monitoring system which is adequately designed and operated to detect releases or to define the rate and extent of contaminant migration from a regulated unit (landfill, land treatment facility, or surface impoundment) as required under 40 CFR Parts 265 and 270.

A CME involves extensive office as well as field work and should be done by technical enforcement staff with the involvement of a professional experienced in geology. The individual conducting the evaluation should have substantial knowledge of hydrogeological site characterizations, the design and construction of ground-water monitoring systems, ground-water sampling, waste characteristics, solute transport, RCRA regulations and enforcement authorities, and site history. The office component is performed largely by an experienced hydrogeologist or geotechnical engineer who is part of technical enforcement staff or available to it. A chemist would often be a valuable asset. The field component requires the participation of the same level individual assisted, if necessary, by a field inspector. The average level of effort for a CME is forty (40) man days. A summary of the CME process follows:

Activity	Persons involved
Pre-CME Planning	• technical enforcement staff • professional experienced in geology • field inspector
CME office evaluation of system design	• professional experienced in hydrogeology • technical enforcement staff
CME field evaluation of system operation/verification of system design CME report preparation	• professional experienced in hydrogeology/engineering • technical enforcement staff • field inspector • experienced hydrogeologist or geotechnical engineer, and chemist (where necessary) • technical enforcement staff
Review of CME report	• experienced hydrogeologist or geotechnical engineer, and chemist (where necessary) • field inspector
Follow-up inspection	• technical enforcement staff • hydrogeologist

CME's should focus on evaluating system design if system design is not sufficiently known in order to assess its adequacy. Where design is of the system is already well understood, the CME should evaluate system operation and maintenance more thoroughly. The rationale for setting these priorities is that until system design is adequately understood, little may be gained from a detailed scrutiny of system operation. Conversely, once an adequate evaluation of system design has been completed, further examination of static, site characteristics during subsequent CME's becomes superfluous. It should be noted that re-evaluation of various site characteristics may be necessary (e.g., seasonally influenced characteristics, new wells, redevelopment of existing wells. Further, those conducting this evaluation should not hesitate to take samples when contamination is observed or suspected. The CME should be scheduled to coincide with a round of sampling at the facility in order to observe the implementation of the sampling and analysis plan, and to facilitate the collection of split samples if deemed necessary. EPA initiated samples may be taken at any time. A summary of the activities of the office and field components of a CME process follows:

A. Office Evaluation

1. Technical evaluation of the site geological characterization including geomorphology and structural geology, stratigraphy, petrology, geochemistry beneath the site and any solid waste management units (SWMUs) close enough to be of concern.

2. Technical evaluation of the site ground-water hydrological characterization, including identification and description of the uppermost aquifer, potentiometric surface, vertical and horizontal gradients, and hydraulic conductivity beneath the site and any SWMUs close enough to be of concern.

3. Technical evaluation of the criteria for horizontal well placement and screen lengths of detection monitoring wells, upgradient and downgradient.

4. Technical evaluation of the criteria for horizontal well placement and screen lengths of assessment monitoring wells.

5. Technical evaluation of the criteria for drilling method and monitoring well design and construction.

6. Technical evaluation of the assessment plan or outline.

7. Technical evaluation of the sampling and analysis plan.

To the extent possible, the enforcement official should use existing information to evaluate the design of the owner-operator's ground-water monitoring system.

B. Field Evaluation

1. Technical evaluation of the implementation of the sampling and analysis plan.

2. Field verification of the number, locations and screen depths of ground-water monitoring wells and piezometers, and water levels (where deemed necessary).

3. Possible collection of samples for analysis by a contract laboratory or EPA/State laboratory to assist in the verification of analytical precision and methodology of facility procedures. Samples may either be owner-operator splits if the Agency approves of the sampling procedure, or EPA-collected.

4. Possible implementation of confirmatory geophysical methods to verify facility assessment of hydrogeology or contaminant distribution.

C. Information Sources

A CME permits the determination of the adequacy of ground-water monitoring systems through a detailed technical appraisal of site hydrogeology, monitoring well placement, monitoring well design and construction, sampling and analysis plan, data presentation, and, where appropriate, assessment plan.

The detailed technical evaluation of system design should be initiated by locating the source(s) of information pertinent to the facility to be inspected. Sources of information include, but are not limited to:

1. U.S. EPA Regional Offices
2. State regulatory agencies
3. U.S. Geological Survey (hydrogeologic information)
4. State geological surveys, state conservationist county soil surveys
5. Owner-operator files
6. Academic institutions
7. State water surveys
8. Aerial photographs

The following documents are valuable sources of information which contain the following pertinent information:

1. Part A of the RCRA Permit Application:
   a. A list of activities conducted by the applicant which require a RCRA permit.

   b. Primary Standard Industrial Codes (SIC) which best reflect the principal products handled or services provided by the facility.

   c. A description of the processes used for treating, storing and disposing of hazardous waste.

   d. Specification of the hazardous wastes designated under 40 CFR Part 261 to be treated, stored, or disposed of at the facility, and an estimate of the quantity and delivery timing of such wastes.

2. Part B of the RCRA Permit Application:

   a. A general description of the facility.

   b. Chemical and physical analyses of the hazardous wastes handled at the facility.

   c. A copy of the waste analysis plan.

   d. A copy of the general inspection schedule.

   e. A topographic map (scale: 1" = 200').

   f. Aerial photographs.

   g. Geologic and hydrogeologic characterization information.

   h. Description of the ground-water monitoring system.

   i. Sampling and Analysis Plan.

   j. Ground-Water Quality Assessment Plan Outline.

   k. Monitoring well construction details.

   l. Information about nearby ground-water and surface water usage.

Parts A and B of the RCRA permit application should be available at sources.

3. Contractor geotechnical reports

   a. Description of waste handling procedures.

   b. Geologic and hydrogeologic data (site-specific and regional).

   c. Description of ground-water monitoring system.

   d. Facility layout.

   e. Monitoring well construction details.

   f. Results of geophysical tests.

g. Recommendations to facility operator.

Contractor reports may be available at source numbers 1, 2 and 5.

4. Regional geologic, soil, and/or ground-water reports.

   a. Regional geologic information.

   b. Regional soil maps.

   c. Regional hydrogeologic data.

   d. Information on ground-water usage.

   e. Geochemical data.

   f. Climatic data, precipitation, evapo-transpiration.

Geologic reports should be available from source numbers 3 and 4.

5. Inspection reports or other records or correspondence related to the facility's compliance status.

   a. Records of past violations.

   b. Copies of complaints, administrative orders or case referral packages.

   c. HWDMS reports (compliance monitoring and enforcement log).

   d. Correspondence.

Reports may be available at source numbers 1 and 2.

6. Sampling and Analysis Plan

   a. Sample collection procedures including measurement of static water level evaluation, detection of immiscible layers, well evacuation, sample withdrawal, and <u>in situ</u> or field analyses.

   b. Sample preservation and handling procedures including sample containment, preservation, and special handling considerations.

   c. Chain-of-custody procedures including description of sample labels and seals, field logbook layout, descriptions of chain-of-custody record, sample analysis request sheet and laboratory logbook.

   d. Analytical procedures, and detection limits.

   e. Field and laboratory quality assurance/quality control.

f. Evaluation of the quality of ground-water data, including reporting of low and zero concentration values, significant digits, missing data values, outliners and units of measure.

NOTE: The Sampling and Analysis Plan should be kept at the facility and therefore available to the inspector upon request.

7. Ground-Water Quality Assessment Plan:

a. A description of the detection monitoring system.

b. Discussion of hydrogeologic conditions at the facility.

c. Sampling and analytical methods for those hazardous wastes or hazardous waste constituents previously detected at the facility.

d. A description of the evaluation procedures, including the use of previously gathered ground-water quality data, the owner/operator will use to make the first determination.

e. Description of the approach the owner/operator will use to fully characterize rate and extent of contamination migration (i.e., test borings, mathematical modeling).

f. Discussion of the number, location, and depth of monitoring wells the owner/operator will install to define contaminant migration (in order to define horizontal and vertical dimensions of the contaminant plume).

g. A description of monitoring well construction techniques.

h. A schedule of implementation of all phases of the assessment program.

Assessment plans should be available at source numbers 1 and 2. Assessment plan outlines should be kept at the facility.

When performing the field evaluation, the enforcement official(s) will attempt to fill data gaps with observations.

D. Elements of Office Evaluation of System Design

1. The enforcement official should review the owner/operator's characterization of site hydrogeology and make a determination whether or not the owner/operator has collected enough information on which to base the design of a monitoring program.

a. Boring and well logs.

b. Geotechnical laboratory test results (e.g., permeability, geochemical composites).

c. Contractor geotechnical reports.

d. Results of geophysical tests.

e. Static water level data.

f. *In situ* permeability tests (horizontal)

g. *In situ* permeability tests (vertical)

E. Conclusions that should be reached from the technical office evaluation are:

1. Is the site hydrogeological characterization adequately detailed to identify preferential contaminant migration pathways?

2. Are the horizontal placement, screen lengths and depths of detection monitoring wells theoretically adequate to immediately detect the release of hazardous waste constituents from the regulated unit, and hazard constituents from regulated units subject to 270.14 (c)(iv)?

3. Are the horizontal placement and screen lengths of assessment monitoring wells theoretically adequate to determine the rate and extent of migration and chemical composition of any contaminant plumes?

4. Can the detection monitoring system theoretically differentiate nearby SWMU releases from regulated unit releases? *

5. Are the design and construction criteria for detection ground-water monitoring wells sufficient to provide long-term, unbiased samples of ground-water?

6. Are the design and construction criteria for assessment monitoring wells theoretically adequate to characterize releases of hazardous waste constituents from the regulated unit(s), and hazardous constituents in the case of a regulated unit subject to 270.14 (c)(iv)?

7. Is the sampling and analysis plan theoretically adequate to provide accurate and precise ground-water quality data?

8. Are ground-water quality data presented in a manner that permits an assessment of their significance?

9. Is the statistical method used consistent with the regulatory requirement?

10. Is the assessment plan or outline theoretically adequate to permit determination of the chemical composition, and rate and extent of migration of a release from the regulated unit(s), and to differentiate that contamination from any originating from SWMUs?

* Where it is not possible to differentiate i.e., where SWMUs and regulated units are very close together, any releases would be addressed under 265 assessment monitoring or an analogens requirements under a 3008(h) order.

Section II. Field Evaluation and Verification Preparation

Prior to performing the field evaluation component, it is necessary for the evaluation team to complete a number of preliminary tasks. These tasks include:

1. Development of a site safety plan for the field evaluation. Prior to arriving at the facility, the field evaluation team personnel should have determined the level of protection, decontamination procedures, and other safety precautions necessary.

2. All evaluation team personnel should have credentials or identification that describe their federal or state agency affiliation.

3. The following equipment is recommended to conduct the field evaluation:

   - bound field notebook
   - camera
   - pocket calculator
   - watch with sweep second hand (or stop watch)
   - compass
   - weighted tape measure and water indicator (made of inert material), or electronic interface probe to measure static water levels and total depth of monitoring wells and detect immiscible layers.
   - deionized water, hexane (or laboratory strength cleaner), and sterile, disposalable paper towels or gauze for decontamination of tape measure or probe.
   - sampling equipment, e.g., bailer (made of inert material), monofilament line, properly cleaned.
   - all appropriate forms, e.g., chain-of-custody
   - safety equipment

4. Determination of whether or not samples will be collected. After the technical evaluation of the ground-water monitoring system is completed, the utility of extensive sampling by the evaluating team can be ascertained.

   Samples should be taken when contamination is observed or suspected. The team should develop a project plan prior to entry and may use facility's sampling equipment if it is found to be adequate. Inspection personnel should do appropriate field analyses (pH, specific conductance, temperature) with their own portable field equipment to verify results of facility determinations. The samples will be analyzed to assess the operation of the monitoring system and analytical procedures utilized by the facility.

Section III. Field Evaluation and Verification Activities

The following elements of the ground-water monitoring system design should be verified in the field:

* location of regulated units
* number and location of monitoring wells or clusters
* spacing of monitoring wells or clusters
* static water level measurements (where deemed necessary)
* well elevations, physical condition, labeling (where deemed necessary)

The following elements of the ground-water monitoring system design and operation should be verified and evaluated:

* determination of the presence, where appropriate, of light and dense phase immiscible layers (where deemed necessary)
* sample collection, preservation, and handling procedures, implementation of the sampling and analysis plan
* determination of total well depths
* surficial well construction
* general site conditions
* site sketch

The office evaluation component identifies deficiencies in the design of ground-water monitoring systems, either detection or assessment. The field evaluation and verification component of a CME serves a dual purpose. It first identifies discrepencies between system design as presented and constructed. Secondly, the field component of the CME is an evaluation of system operation and an opportunity to collect data necessary to draw conclusions about the adequacy of the ground-water monitoring program (detection or assessment), e.g., a reassessment of site hydrogeological characterization using direct and/or indirect techniques. The following are key considerations in conducting the field evaluation.

A. Number and Location of Monitoring Wells

During the evaluation, the evaluation team should verify that the total number of wells that are described in the assessment plan outline or plan are found in the field, and that all wells are adequately maintained. Approximate locations of each well should be field checked against those presented on site maps in the owner/operator's Part B permit application.

To accomplish this, the distance between wells and other features may be accurately measured using a surveyor's chain, while other measurements may be approximated either by pacing or visual inspection in the case of closely-spaced wells. (Note any scale on the owner/operator's site map, if applicable, and measure using an engineer's scale).

Facilities under detection monitoring must have a sufficient number of wells to identify the presence of a release of contaminants from the hazardous waste management area. Upgradient wells should be positioned so that they are not affected by the facility's operations and provide background ground-water quality data. Areas of low or variable hydraulic gradient and/or upgradient sources of contamination are common in parts of the country and can pose problems in establishing the upgradient quality of ground-water. In those situations, the emphasis of the field work should be determining whether a release has occurred. Downgradient wells must be located along the edge of the waste management area so that the owner/operator can immediately detect leakage (refer to TEGD for detail). Other wells located within the facility boundaries should be identified on a facility map.

B. Assessment Monitoring

A facility in assessment monitoring will have additional well clusters located downgradient from the waste unit or along contaminant migration pathways that vary from ground-water flow direction to define the contaminant concentrations and plume configuration. Each well cluster may have several wells, each screened at various intervals to provide the vertical extent of migration.

The evaluation team should verify the locations and vertical sampling intervals of assessment wells or clusters.

C. Static Water Level Elevation

The inspector should determine, for each well, the depth to standing water. Measurements are taken from reference point on the well casing down to the static water level. Measurements must be accurate to $\pm$ 0.01 foot. It is recommended that levels be recorded using electronic sounding devices of M-scope, otherwise a stainless steel (or other inert material) measuring tape with a weighted end may be used. The tape is coated for the last foot with a water indicator and lowered into the water a few tenths of a foot and the nearest .01 foot at the measuring point recorded. The depth to water is obtained by subtracting the wetted length from the nearest foot reading at the measuring point.

Measurements are generally recorded in hundredths of feet. To convert from inches to feet:

$$\text{inches} \times 0.0833 = \text{feet}$$

Should the owner/operator's Sampling and Analysis Plan, waste analysis or historical data indicate the presence of light or dense phase immiscible layers, an interface probe should be used to register the top of the organic layer, and establish the thickness of the immiscible layer overlying the organic/water interface. Dense phase immiscible layers can be measured by lowering the interface probe to the bottom of the well where the probe registers the location of an organic/water interface.

NOTE: Engineering chain tapes are usually graduated to the nearest 0.01 foot for the first foot only.

D. Sample Collection

Sample collection should be divided into three phases:

1. Sampling of light/dense phase immiscibles (where necessary),

2. Well evacuation, and

3. Sample withdrawal.

Depending on the waste characteristics, the owner/operator's Sampling and Analysis Plan may not have provisions for sampling of light/dense phase immiscibles. Where light and/or dense phase immiscibles are present, the owner/operator must obtain discrete samples of them. The well should be designed to capture light phase immiscibles "floating" at specific screened intervals, and to collect "sinkers" within dense phase sampling cups at the bottom of the well.

- Sampling of Light Phase Immiscibles (May not be applicable to the facility)

Sampling for light immiscible fractions must precede well evacuation. A bottom filling fluorocarbon resin or stainless steel 316, 304 or 2205 bailer should be lowered to the predetermined levels for collection. Care must be taken to avoid actions which may disturb the interface between the organic and aqueous phases. Plastic sheets should be laid out next to the well to protect from surface contaminants when the bailer is being assembled.

- Sampling of Dense Phase Immiscibles (May not be applicable to the facility)

Collection of dense phase immiscibles should be done before well evacuation. Either a clean positive gas displacement bladder pump or bottom filling fluorocarbon resin or stainless steel 316, 304 or 2205 bailer is lowered gently to collect a discrete sample from the bottom dense phase sampling cup. Any motions that agitate the standing water should be restricted. Pumping rates should be kept to 100 ml/min or less to avoid turbulence.

- Well Evacuation

The owner/operator must remove standing water from the well and filter pack to obtain a representative formation sample. Important points to consider during evacuation are:

1. All well evacuation materials entering the well should be composed of inert or refractory materials (i.e., fluorocarbon resins or stainless steel 316, 304 or 2205).

2. Note the type of purging equipment used. Peristaltic pumps, gas-lift pumps, centrifugal pumps and venturi pumps may increase volatilization and cause high pressure differentials that can result in fluctuations in many analytical parameters, but are acceptable for purging provided that sufficient time be allowed for water to stabilize prior to sampling.

3. Nondedicated sampling equipment must be thoroughly decontaminated, cleaned, and rinsed between wells. This is especially important where interface probes are used to detect viscous organics.

4. Sampling personnel should wear clean gloves during all purging and sampling activities.

5. Discharge rate should be accurately measured.

6. Low yielding wells should be evacuated to practical dryness (some water may remain below the pump intake or from discharge lines not equipped with check valves).

7. High yielding wells should have a minimum of three casing volumes removed prior to sampling or that quantity sufficient to remove stagnant water from the well and filter pack.

8. Wells should be protected from surface contaminants entering during evacuation and sampling.

9. The following table may be helpful in determining the volume of water contained in a one-foot casing section:

ID (inches)	Gallons	Metric
0.5	0.01	37.8 ml
0.75	0.02	75.8 ml
1.00	0.04	15.5 cl
1.25	0.06	22.7 cl
1.50	0.09	34.09 cl
2.00	0.16	60.61 cl
3.00	0.37	1.40 liter
4	0.65	2.46 liter
6	1.47	5.56 liter
8	2.61	9.89 liter
10	4.08	15.45 liter

10. All ground-water evacuated from a well which is suspected of being hazardous should be properly managed.

To obtain the total volume of water contained in the well, simply multiply by the height (in feet) of the water column. It may be necessary to verify the diameter of the well casing.

E. Sample Withdrawal

The inspector should look for any sampling technique that may result in the procurement of a contaminated or otherwise altered sample. The following points should be kept in mind during sampling:

1. Sampling devices should be composed of fluorocarbon resins or stainless 304, 316 or 2205.

2. Where dedicated pumps are not used, pump equipment and probes must be thoroughly cleaned between wells. Equipment should first be wiped to remove excess contaminants and to improve cleaning efficiency. Subsequent cleaning procedures should entail:

When Inorganic Constituents are Suspected:

0.1N HCL or HNO_3 rinse
Distilled or deionized water rinse

When Organic Constituents are Suspected:

Nonphosphate detergent wash
Tap water rinse
Distilled water rinse
Acetone rinse
Hexane rinse
Adequate drying time

3. Pumping rates should not exceed 100 ml/min when sampling for volatiles and pH. Higher pumping rates are acceptable for other parameters.

4. Positive gas displacement bladder pumps should be operated in a continuous manner so that they do not produce pulsating samples that are aerated in the return tube or upon discharge.

5. Check valves should be designed and inspected to assure that fouling problems do not reduce delivery capabilities or result in aeration of the sample.

6. Sampling equipment (especially bailers) should never be dropped into the well as this will cause degassing of the water on impact.

7. The bailer's contents should be transferred to a suitable sample container in a way that will minimize agitation and aeration. *

* Filling the VOA containers from the bottom of the bailer causes less turbulence than pouring its contents from the top. It is recommended, therefore, to fill the containers from the bottom of the bailer whenever possible.

8. Samples should not be composited in one large container and later transferred to others.

9. Clean sampling equipment should not be placed directly on the ground or other contaminated surfaces prior to insertion into wells.

10. Sampling in low yielding wells should be performed as soon as there is enough water present to collect the sample.

11. Volatile parameters should be collected first.

12. Probes used for in situ analyses should not be inserted into sample containers.

F. In Situ or Field Analyses

Physically and chemically labile parameters must be tested either in the borehole using a probe (in situ) or immediately upon withdrawal using a field test kit.

1. Analyses must be performed both after well evacuation and sample collection.

2. Field instruments should be calibrated according to manufacturer's specifications and be consistent with SW-846 (Test Methods for Evaluating Solid Waste-Physical/Chemical Methods)

G. Sample Preservation and Handling

Samples must be contained and preserved by approved methods to maintain the integrity of the sample. Improper preservation and handling may alter parameter levels in the sample. Key points to note during the inspection include:

1. Procured samples should be transferred directly into the container specifically prepared for that given parameter or set of compatible parameters (e.g., dissolved metals). Samples should not be composited into a common container to be subsequently split in the laboratory.

2. Samples should be collected in a manner that minimizes turbulence and agitation.

3. Volatile Organics Analysis (VOA) vial should be poured so that it overflows leaving no headspace or bubbles in the vial. Its cap should be lined with a fluorocarbon resin.

4. Samples for metals analysis can be collected in polyethylene containers with polypropylene caps, or in glass bottles with fluorocarbon resin lined caps.

5. Samples for organic analysis should be collected in glass bottles with fluorocarbon resin.

H. Special Handling Considerations

- Organics

1. Samples must not be filtered.

2. Samples must not be transferred from one container to another.

- Metals

1. Samples collected for metals analysis should be split into two samples. One portion filtered through a 0.45 u filter for dissolved metals and the second portion remaining unfiltered for total metals analysis. Samples should be filtered as soon as possible to minimize the impacts of pH and Eh changes.

2. Both samples should be preserved with nitric acid to pH <2.

The recommended procedures for sampling and preservation are presented in Table 1.

I. Quality Assurance/Quality Control

To ensure the reliability of field-generated data, the owner/operator's Sampling and Analysis Plan should incorporate the use of trip and equipment blanks during sampling to verify that sample collection and handling processes have not affected the quality of the field samples. Field verification of quality control procedures will include:

1. The use of trip and equipment blanks.

   - Trip blanks: Used to determine if contamination was introduced from the sample containers through normal handling.

   - Equipment blanks: Used to determine if contamination may be a result of improper cleaning.

2. Calibration of monitoring and sampling equipment.

3. Proper decontamination and cleaning of nondedicated equipment.

J. Chain-of-Custody Procedures

Field verification of the owner/operator's chain-of-custody procedures will contain the following elements:

1. Sample labels for proper identification.

Parameter	Recommended Container[b]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis
		Indicators of Ground-Water Contamination[c]		
pH	T,P,G	Field determined	None	25 ml
Specific conductance	T,P,G	Field determined	None	100 ml
TOC	G. teflon-lined cap	Cool 4°C, HCl to pH <2	28 days	4 x 15 ml
TOX	G. amber, Teflon lined cap	Cool 4°C, add 1 ml of 1.1M sodium sulfite	7 days	4 x 15 ml
		Ground-Water Quality Characteristics		
Chloride	T,P,G	4°C	28 days	50 ml
Iron Manganese Sodium	T, P	Field Acidified to pH <2 with HNO_3	6 months	200 ml
Phenols	G	$4°C/H_2SO_4$ to pH <2	28 days	500 ml
Sulfate	T,P,G	Cool, 4°C	28 days	50 ml
		EPA Interim Drinking Water Characteristics		
Arsenic Barium Cadmium Chromium Lead Mercury Selenium Silver	T,P Dark Bottle	Total Metals Field acidified to pH <2 with HNO_3 Dissolved Metals 1. Field filtration (0.45 micron) 2. Acidify to pH <2 with HNO_3	6 months 6 months	1,000 ml 1,000 ml
Fluoride	T,P	Field acidified to pH <2 with HNO_3	28 days	300 ml
Nitrate	T,P,G	$4°C/H_2SO_4$ to pH <2	14 days	1,000 ml

Parameter	Recommended Container[b]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis
Endrin Lindane Methoxychlor Toxaphene 2,4,D 2,4,5 TP Silvex	T,G	Cool, 4°C	7 days	2,000
Radium Gross Alpha Gross Beta	P,G	Field acidified to pH <2 with HNO_3	6 months	1 gallon
Coliform bacteria	PP, G (sterilized)	Cool, 4°C	6 hours	200 ml
		Other Ground-Water Characteristics of Interest		
Cyanide	P,G	Cool, 4°C, NaOH to pH >12	14 days	500 ml
Oil and Grease	G only	Cool, 4°C H_2SO_4 to pH <2	28 days	100 ml
Semivolatile, nonvolatile organics	T,G	Cool, 4°C	14 days	60 ml
Volatiles	G,T-lined	Cool, 4°C	14 days	60 ml

[a]References: Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846 (2nd edition, 1982).
Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020
Standard Methods for the Examination of Water and Wastewater, 16th edition (1985).

[b]Container Types:

P = Plastic (polyethylene)
G = Glass
T = Teflon
PP = Polypropylene

[c]Based on the requirements for detection monitoring (§265.93), the owner/operator must collect a sufficient volume of ground-water to allow for the analysis of four separate replicates.

2. <u>Sample seals</u> to ensure integrity of the collected samples until they are reopened.

3. <u>Field logbook</u> to record ground-water monitoring program information.

4. <u>Chain-of-custody record</u> to track sample possession.

K. Sample Labels

Ideally, sample labels should contain the following information:

1. Sample identification number (mandatory).

2. Name of collector.

3. Date and time of collection.

4. Monitoring well.

5. Parameter(s) requested.

L. Sample Seals

Seals may be important in the event that samples leave the owner/operator's immediate control through shipment to laboratory. Seals thus provide assurance that samples have not been disturbed or tampered with.

M. Field Logbook

An owner/operator or the individual designated to perform ground-water monitoring operations should keep an up-to-date field logbook which documents the following:

1. Identification of well
2. Well depth
3. Static water level depth and measurement technique
4. Presence of immiscible layers and detection method
5. Well yield - high or low
6. Collection method for immiscible layers and sample identification numbers
7. Well evacuation procedure/equipment
8. Sample withdrawal procedure/equipment
9. Date and time of collection

10. Well sampling sequence
11. Types of sample containers used and sample identification numbers
12. Preservative(s) used
13. Parameters requested for analysis
14. Field analysis data and method(s)
15. Sample distribution and transporter
16. Field observations on sampling event
17. Name of collector

N. Chain-of-Custody Record

To establish the documentation necessary to trace sample possession from time of collection, a chain-of-custody record should be filled out and accompany every sample. The record should contain the following type of information:

1. Sample number
2. Signature of collector
3. Date and time of collection
4. Sample type (e.g., ground-water, immiscible layer)
5. Identification of well
6. Number of containers
7. Parameters requested for analysis
8. Signature of person(s) involved in the chain of possession
9. Inclusive date of possession

O. Total Well Depth

During well evacuation and/or purging, the total well depth should be verified for each well in the monitoring system. It is recommended that the use of sounding devices or weighted stainless steel measuring tape be used in the event the well cannot be pumped or bailed to dryness. Measurements are taken from the top of the well casing and should be accurate to $\pm$ 0.01 foot.

P. Surficial Well Inspection

Visual inspection of surficial well construction and condition will aid in determining the adequacy of the owner/operator ground-water monitoring system design. Important considerations include:

1. Wells adequately maintained (not overgrown by vegetation or impaired by neglect or misuse), and properly labeled

2. Wells protected and secured with steel protective cap and lock

3. Wells sealed properly at surface to prevent surface contaminants from entering the well

4. Casing material

5. Top of casing elevation

6. Turbidity of collected samples

Q. Field Observations

While in the field it is important to record as many observations as possible. Site characteristics should include:

1. Topographic relief - Lay of the land, slopes etc.

2. Water Bodies - Direction and distance to streams, rivers, ponds, lakes, estuaries, ocean, etc.

3. Surface Features - Soil type, rock outcrops, leachate surface seeps, dominant vegetation types, if applicable.

4. Man-Made Features (particularly ones affecting hydrogeology) - Nearby industrial wells, drainage ditches, underground conduits and drains, impoundments, also note area water supply sources.

R. Site Sketch

A map of the site should be available to the inspector from the Part B permit application materials. If a copy of the site map is not available at the time of the field inspection, the inspector should sketch the facility. The sketch should include:

1. Location of regulated units

2. Location of wells

3. Location of major buildings and important surface features

4. Drainage pattern and ground-water flow direction

5. Location of drains and seepage areas

6. North arrow and rough scale

Section IV. Sampling and Analysis

When the owner/operator's ground-water monitoring system design has been determined to be satisfactory, subsequent CMEs focus on system operation and, therefore, may involve sampling and analysis of ground-water samples collected at the facility. If the owner/operator sample preparation procedures are deemed inconsistent with EPA-approved methods, the inspector should request that the owner/operator sample according to recommended procedures described in Section 3.2.3 in addition to the methods employed by the owner/operator, with the sample results analyzed and compared. Additionally, the inspector should send a duplicate (split) sample, collected and prepared using EPA-approved methods, to the enforcement authority's laboratory for analysis.

Section V. Conclusions and Recommendations

Has the owner/operator adequately characterized site hydrogeology?

Is the detection monitoring system adequately designed and constructed to immediately detect any contaminant release from the regulated unit(s) and differentiate where possible, such releases from nearby SWMU releases?

Are the procedures used to make a first determination of contamination adequate?

Is the operation of the ground-water monitoring system adequate to permit immediate detection of a release of contaminants from hazardous waste management areas?

Do the assessment monitoring wells, given site hydrogeologic conditions, define the extent and concentration of contamination in the horizontal and vertical planes?

Are the assessment monitoring wells adequately designed and constructed?

Are the sampling and analysis procedures adequate to provide representative samples of ground-water in the uppermost aquifer?

Do the procedures used for evaluation of assessment monitoring data result in determinations of the rate of migration, extent of migration, and hazardous waste constituent composition of the contaminant plume?

Are the data collected at sufficient duration and frequency to adequately determine the rate of migration?

Is the schedule of implementation adequate?

Is the owner/operator's assessment monitoring plan adequate?

If the owner/operator had to implement his assessment monitoring plan, was it implemented satisfactorily?

Based on the results of the evaluation, deficiencies in network design, information gaps, and operational inadequacies can be clearly identified and listed. In order to assist the various enforcement authorities involved in bringing the facility into compliance, the deficiencies may be categorized into major or minor areas of noncompliance. Major deficiencies would involve shortcomings in network design or gross inadequacies in sampling and/or analysis that would seriously impair detection or assessment monitoring functions. Minor deficiencies, though important, may not necessitate case development, but rather issuance of deficiency notices to bring about desired changes. Based on conclusions gained from the CME, the evaluation team members should clearly define the recommendations. These recommendations will thus provide appropriate guidance toward obtaining more information that may be required for administrative or judicial action.

APPENDIX A

COMPREHENSIVE GROUND-WATER MONITORING EVALUATION WORKSHEET

The following worksheets have been designed to assist the enforcement officer/technical reviewer in evaluating the ground-water monitoring system an owner/operator uses to collect and analyze samples of ground water. The focus of the worksheets is technical adequacy as it relates to obtaining and analyzing representative samples of ground water. The basis of the worksheets is the final RCRA Ground Water Monitoring Technical Enforcement Guidance Document which describes in detail the aspects of ground-water monitoring which EPA deems essential to meet the goals of RCRA.

Appendix A is not a regulatory checklist. Specific technical deficiencies in the monitoring system can, however, be related to the regulations as illustrated in Figure 4.3 taken from the RCRA Ground-Water Monitoring Compliance Order Guide (COG) (included at the end of the appendix). The enforcement officer, in developing an enforcement order, should relate the technical assessment from the worksheets to the regulations using figure 4.3 from the COG as a guide.

I. <u>Office Evaluation - Technical Evaluation of the Design of the Ground-water Monitoring System</u>

A. Review of relevant documents:

1. What documents were obtained prior to conducting the inspection:

a. RCRA Part A permit application? (Y/N) ___
b. RCRA Part B permit application? (Y/N) ___
c. Correspondence between the owner/operator and appropriate agencies or citizen's groups? (Y/N) ___
d. Previously conducted facility inspection reports? (Y/N) ___
e. Facility's contractor reports? (Y/N) ___
f. Regional hydrogeologic, geologic, or soil reports? (Y/N) ___
g. The facility's Sampling and Analysis Plan? (Y/N) ___
h. Ground-water Assessment Program Outline (or Plan, if the facility is in assessment monitoring)? (Y/N) ___
i. Other (specify) ______________________

B. Evaluation of the Owner/Operator's Hydrogeologic Assessment:

1. Did the owner/operator use the following direct techniques in the hydrogeologic assessment:

a. Logs of the soil borings/rock corings (documented by a professional geologist, soil scientist, or geotechnical engineer)? (Y/N) ___
b. Materials tests (e.g., grain size analyses, standard penetration tests, etc.)? (Y/N) ___
c. Piezometer installation for water level measurements at different depths? (Y/N) ___
d. Slug tests? (Y/N) ___

e. Pump tests? (Y/N) ___
f. Geochemical analyses of soil samples? (Y/N) ___
g. Other (specify) (e.g., hydrochemical diagrams and wash analysis) ___________________________
____
____

2. Did the owner/operator use the following indirect techniques to supplement direct techniques data:

   a. Geophysical well logs? (Y/N) ___
   b. Tracer studies? (Y/N) ___
   c. Resistivity and/or electromagnetic conductance? (Y/N) ___
   d. Seismic Survey? (Y/N) ___
   e. Hydraulic conductivity measurements of cores? (Y/N) ___
   f. Aerial photography? (Y/N) ___
   g. Ground penetrating radar? (Y/N) ___
   h. Other (specify) ___________________________
   ____

3. Did the owner/operator document and present the raw data from the site hydrogeologic assessment? (Y/N) ___

4. Did the owner/operator document methods (criteria) used to correlate and analyze the information? (Y/N) ___

5. Did the owner/operator prepare the following:

   a. Narrative description of geology? (Y/N) ___
   b. Geologic cross sections? (Y/N) ___
   c. Geologic and soil maps? (Y/N) ___
   d. Boring/coring logs? (Y/N) ___
   e. Structure contour maps of the differing water bearing zones and confining layer? (Y/N) ___
   f. Narrative description and calculation of ground-water flows? (Y/N) ___
   g. Water table/potentiometric map? (Y/N) ___
   h. Hydrologic cross sections? (Y/N) ___

6. Did the owner/operator obtain a regional map of the area and delineate the facility? (Y/N) ___

   If yes, does this map illustrate:

   a. Surficial geology features? (Y/N) ___
   b. Streams, rivers, lakes, or wetlands near the facility? (Y/N) ___
   c. Discharging or recharging wells near the facility? (Y/N) ___

7. Did the owner/operator obtain a regional hydrogeologic map? (Y/N) ___

   If yes, does this hydrogeologic map indicate:

   a. Major areas of recharge/discharge? (Y/N) ___
   b. Regional ground-water flow direction? (Y/N) ___
   c. Potentiometric contours which are consistent with observed water level elevations? (Y/N) ___

8. Did the owner/operator prepare a facility site map? (Y/N) ___

   If yes, does the site map show:

   a. Regulated units of the facility (e.g., landfill areas, impoundments)? (Y/N) ___
   b. Any seeps, springs, streams, ponds, or wetlands? (Y/N) ___
   c. Location of monitoring wells, soil borings, or test pits? (Y/N) ___
   d. How many regulated units does the facility have? ___
      If more than one regulated unit then,
      o Does the waste management area encompass all regulated units? (Y/N) ___
        Or
      o Is a waste management area delineated for each regulated unit? (Y/N) ___

C. Characterization of Subsurface Geology of Site

1. Soil boring/test pit program:

   a. Were the soil borings/test pits performed under the supervision of a qualified professional? (Y/N) ___
   b. Did the owner/operator provide documentation for selecting the spacing for borings? (Y/N) ___
   c. Were the borings drilled to the depth of the first confining unit below the uppermost zone of saturation or ten feet into bedrock? (Y/N) ___
   d. Indicate the method(s) of drilling:
      o Auger (hollow or solid stem) ___
      o Mud rotary ___
      o Reverse rotary ___
      o Cable tool ___
      o Jetting ___
      o Other (specify) ___
   e. Were continuous sample corings taken? (Y/N) ___

f. How were the samples obtained (checked method[s])
   - o Split spoon ____
   - o Shelby tube, or similar ____
   - o Rock coring ____
   - o Ditch sampling ____
   - o Other (explain) ____

____
____
____

g. Were the continuous sample corings logged by a qualified professional in geology? (Y/N) ___

h. Does the field boring log include the following information:
   - o Hole name/number? (Y/N) ___
   - o Date started and finished? (Y/N) ___
   - o Driller's name? (Y/N) ___
   - o Hole location (i.e., map and elevation)? (Y/N) ___
   - o Drill rig type and bit/auger size? (Y/N) ___
   - o Gross petrography (e.g., rock type) of each geologic unit? (Y/N) ___
   - o Gross mineralogy of each geologic unit? (Y/N) ___
   - o Gross structural interpretation of each geologic unit and structural features (e.g., fractures, gouge material, solution channels, buried streams or valleys, identification of depositional material)? (Y/N) ___
   - o Development of soil zones and vertical extent and description of soil type? (Y/N) ___
   - o Depth of water bearing unit(s) and vertical extent of each? (Y/N) ___
   - o Depth and reason for termination of borehole? (Y/N) ___
   - o Depth and location of any contaminant encountered in borehole? (Y/N) ___
   - o Sample location/number? (Y/N) ___
   - o Percent sample recovery? (Y/N) ___
   - o Narrative descriptions of:
     - -- Geologic observations? (Y/N) ___
     - -- Drilling observations? (Y/N) ___

i. Were the following analytical tests performed on the core samples:
   - o Mineralogy (e.g., microscopic tests and x-ray diffraction)? (Y/N) ___
   - o Petrographic analysis:
     - - degree of crystallinity and cementation of matrix? (Y/N) ___
     - - degree of sorting, size fraction (i.e., sieving), textural variations? (Y/N) ___

- rock type(s)? (Y/N) ___
- soil type? (Y/N) ___
- approximate bulk geochemistry? (Y/N) ___
- existence of microstructures that may effect or indicate fluid flow? (Y/N) ___

o Falling head tests? (Y/N) ___
o Static head tests? (Y/N) ___
o Settling measurements? (Y/N) ___
o Centrifuge tests? (Y/N) ___
o Column drawings? (Y/N) ___

D. Verification of subsurface geological data

1. Has the owner/operator used indirect geophysical methods to supplement geological conditions between borehole locations? (Y/N) ___
2. Do the number of borings and analytical data indicate that the confining layer displays a low enough permeability to impede the migration of contaminants to any stratigraphically lower water-bearing units? (Y/N) ___
3. Is the confining layer laterally continuous across the entire site? (Y/N) ___
4. Did the owner/operator consider the chemical compatibility of the site-specific waste types and the geologic materials of the confining layer? (Y/N) ___
5. Did the geologic assessment address or provide means for resolution of any information gaps of geologic data? (Y/N) ___
6. Do the laboratory data corroborate the field data for petrography? (Y/N) ___
7. Do the laboratory data corroborate the field data for mineralogy and subsurface geochemistry? (Y/N) ___

E. Presentation of geologic data

1. Did the owner/operator present geologic cross sections of the site? (Y/N) ___
2. Do cross sections:
   a. identify the types and characteristics of the geologic materials present? (Y/N) ___
   b. define the contact zones between different geologic materials?
   c. note the zones of high permeability or fracture? (Y/N) ___
   d. give detailed borehole information including:
      o location of borehole? (Y/N) ___
      o depth of termination? (Y/N) ___
      o location of screen (if applicable)? (Y/N) ___
      o depth of zone(s) of saturation? (Y/N) ___
      o backfill procedure?

3. Did the owner/operator provide a topographic map which was constructed by a licensed surveyor? (Y/N) ___
4. Does the topographic map provide:
   a. contours at a maximum interval of two-feet? (Y/N) ___
   b. locations and illustrations of man-made features (e.g., parking lots, factory buildings, drainage ditches, storm drains, pipelines, etc.)? (Y/N) ___
   c. descriptions of nearby water bodies? (Y/N) ___
   d. descriptions of off-site wells? (Y/N) ___
   e. site boundaries? (Y/N) ___
   f. individual RCRA units? (Y/N) ___
   g. delineation of the waste management area(s)? (Y/N) ___
   h. well and boring locations? (Y/N) ___
5. Did the owner/operator provide an aerial photograph depicting the site and adjacent off-site features? (Y/N) ___
6. Does the photograph clearly show surface water bodies, adjacent municipalities, and residences and are these clearly labelled? (Y/N) ___

F. Identification of Ground-Water Flowpaths

1. Ground-water flow direction

   a. Was the well casing height measured by a licensed surveyor to the nearest 0.01 feet? (Y/N) ___
   b. Were the well water level measurements taken within a 24 hour period? (Y/N) ___
   c. Were the well water level measurements taken to the nearest 0.01 feet? (Y/N) ___
   d. Were the well water levels allowed to stabilize after construction and development for a minimum of 24 hours prior to measurements? (Y/N) ___
   e. Was the water level information obtained from (check appropriate one):
      o multiple piezometers placed in single borehole? ___
      o vertically nested piezometers in closely spaced separate boreholes? ___
      o monitoring wells ___

f. Did the owner/operator provide construction details for the piezometers? (Y/N) ___

g. How were the static water levels measured (check method(s).
- o Electric water sounder ___
- o Wetted tape ___
- o Air line ___
- o Other (explain) ___

____

h. Was the well water level measured in wells with equivalent screened intervals at an equivalent depth below the saturated zone? (Y/N) ___

i. Has the owner/operator provided a site water table (potentiometric) contour map? If yes,
- o Do the potentiometric contours appear logical and accurate based on topography and presented data? (Consult water level data) (Y/N) ___
- o Are ground-water flow-lines indicated? (Y/N) ___
- o Are static water levels shown? (Y/N) ___
- o Can hydraulic gradients be estimated? (Y/N) ___

j. Did the owner/operator develop hydrologic cross sections of the vertical flow component across the site using measurements from all wells? (Y/N) ___

k. Do the owner/operator's flow nets include:
- o piezometer locations? (Y/N) ___
- o depth of screening? (Y/N) ___
- o width of screening? (Y/N) ___
- o measurements of water levels from all wells and piezometers? (Y/N) ___

2. Seasonal and temporal fluctuations in ground-water level

a. Do fluctuations in static water levels occur? (Y/N) ___
- o If yes, are the fluctuations caused by any of the following:

-- Off-site well pumping (Y/N) ___

-- Tidal processes or other intermittent natural variations (e.g., river stage, etc.) (Y/N) ___

-- On-site well pumping (Y/N) ___

-- Off-site, on-site construction or changing land use patterns (Y/N) ___

-- Deep well injection (Y/N) ___

-- Seasonal variations (Y/N) ___

-- Other (specify) _______________________

b. Has the owner/operator documented sources and patterns that contribute to or affect the ground-water patterns below the waste management? (Y/N) ___
c. Do water level fluctuations alter the general ground-water gradients and flow directions? (Y/N) ___
d. Based on water level data, do any head differentials occur that may indicate a vertical flow component in the saturated zone? (Y/N) ___
e. Did the owner/operator implement means for gauging long term effects on water movement that may result from on-site or off-site construction or changes in land-use patterns? (Y/N) ___

3. Hydraulic conductivity

a. How were hydraulic conductivities of the subsurface materials determined?
   o Single-well tests (slug tests)? (Y/N) ___
   o Multiple-well tests (pump tests) (Y/N) ___
   o Other (specify) ___
b. If single-well tests were conducted, was it done by:
   o Adding or removing a known volume of water, or (Y/N) ___
   o Pressurizing well casing (Y/N) ___
c. If single well tests were conducted in a highly permeable formation, were pressure transducers and high-speed recording equipment used to record the rapidly changing water levels? (Y/N) ___
d. Since single well tests only measure hydraulic conductivity in a limited area, were enough tests run to ensure a representative measure of conductivity in each hydrogeologic unit? (Y/N) ___
e. Is the owner/operator's slug test data (if applicable) consistent with existing geologic information (e.g., boring logs)? (Y/N) ___
f. Were other hydraulic conductivity properties determined? (Y/N) ___
g. If yes, provide any of the following data, if available:
   o Transmissivity ___
   o Storage coefficient ___
   o Leakage ___
   o Permeability ___
   o Porosity ___
   o Specific capacity ___
   o Other (specify) ___

4. Identification of the uppermost aquifer

a. Has the extent of the uppermost saturated zone (aquifer) in the facility area been defined? If yes, (Y/N) ___
   o Are soil boring/test pit logs included? (Y/N) ___
   o Are geologic cross-sections included? (Y/N) ___

b. Is there evidence of confining (competent, unfractured, continuous, and low permeability) layers beneath the site? (Y/N) ___
   o If yes, how was continuity demonstrated?

   ____

   ____

c. What is hydraulic conductivity of the confining unit (if present)? ___ CM/Sec
   How was it determined? ___________________________

d. Does potential for other hydraulic communication exist (e.g., lateral incontinuity between geologic units, facies changes, fracture zones, cross cutting structures, or chemical corrosion/alteration of geologic units by leachage? (Y/N) ___
   If yes or no what is the rationale? __________________________
   ____
   ____
   ____

G. Office Evaluation of the Facility's Ground-Water Monitoring System

Monitoring Well Design and Construction:
These questions should be answered for each different well design present at the facility.

1. Drilling Methods

a. What drilling method was used for the well?
   o Hollow-stem auger ___
   o Solid-stem auger ___
   o Mud rotary ___
   o Air rotary ___
   o Reverse rotary ___
   o Cable tool ___
   o Jetting ___
   o Air drill with casing hammer ___
   o Other (specify) ___________________________

b. Were any cutting fluids (including water) or additives used during drilling? (Y/N) ___
   If yes, specify
   Type of drilling fluid ___________________________
   Source of water used ___________________________
   Foam ___________________________
   Polymers ___________________________
   Other ___________________________

c. Was the cutting fluid, or additive, identified? (Y/N) ___
d. Was the drilling equipment steam-cleaned prior to drilling the well? (Y/N) ___
Other methods ______________________________
____
e. Was compressed air used during drilling? (Y/N) ___
o If yes, was the air filtered to remove oil? (Y/N) ___
f. Did the owner/operator document procedure for establishing the potentiometric surface? (Y/N) ___
o If yes, how was the location established?
____
____
____
____
____

g. Formation samples
o Were formation samples collected initially during drilling? (Y/N) ___
o Were any cores taken continuous? (Y/N) ___
If not, at what interval were samples taken? ___________
____

o How were the samples obtained?
- Split spoon ________
- Shelby tube ________
- Core drill ________
- Other (specify) ______________
o Identify if any physical and/or chemical tests were performed on the formation samples (specify) ___________
____
____

2. Monitoring Well Construction Materials

a. Identify construction materials (by number) and diameters (ID/OD)

	Material	Diameter (ID/OD)
o Primary Casing	______	______
o Secondary or outside casing (double construction)	______	______
o Screen	______	______

b. How are the sections of casing and screen connected?
o Pipe sections threaded ____
o Couplings (friction) with adhesive or solvent ____
o Couplings (friction) with retainer screws ____
o Other (specify) ______________________________

c. Were the materials steam-cleaned prior to installation? (Y/N) ___
If no, how were the materials cleaned? ______________________
____

3. Well Intake Design and Well Development

a. Was a well intake screen installed? (Y/N) ___
o What is the length of the screen for the well?
____
o Is the screen manufactured? (Y/N) ___

b. Was a filter pack installed? (Y/N) ___
o What kind of filter pack was employed? ______________________
o Is the filter pack compatible with formation materials? (Y/N) ___
o How was the filter pack installed? ______________________
o What are the dimensions of the filter pack? ______________________
o Has a turbidity measurement of the well water ever been made? (Y/N) ___
o Have the filter pack and screen been designed for the <u>in situ</u> materials? (Y/N) ___

c. Well development
Was the well developed? (Y/N) ___
o What technique was used for well development?
- Surge block ___
- Bailer ___
- Air surging ___
- Water pumping ___
- Other (specify) ______________________

4. Annular Space Seals

a. What is the annular space in the saturated zone directly above the filter pack filled with?
- Sodium bentonite (specify type and grit)
____
- Cement (specify neat or concrete) ______________________
- Other (specify) ______________________
o Was the seal installed by?
- Dropping material down the hole and tamping ___
- Dropping material down the inside of hollow-stem auger ___
- Tremie pipe method ___
- Other (specify) ___

b. Was a different seal used in the unsaturated zone? (Y/N) ___
If yes,
o Was this seal made with?
- Sodium bentonite (specify type and grit) ______________________
____
- Cement (specify neat or concrete) ______________________
- Other (specify) ______________________

o Was this seal installed by?
  - Dropping material down the hole and tamping ______
  - Dropping material down the inside of hollow stem auger ______
  - Other (specify) ______________________________

c. Is the upper portion of the borehole sealed with a concrete cap to prevent infiltration from the surface? (Y/N) ___
d. Is the well fitted with an above-ground protective device and bumper guards? (Y/N) ___
e. Has the protective cover been installed with locks to prevent tampering (Y/N) ___

H. Evaluation of the Facility's Detection Monitoring Program

1. Placement of Downgradient Detection Monitoring Wells

a. Are the ground-water monitoring wells or clusters located immediately adjacent to the waste management area? (Y/N) ___
b. How far apart are the detection monitoring wells?

____
____
____
____

c. Does the owner/operator provide a rationale for the location of each monitoring well or cluster? (Y/N) ___
d. Has the owner/operator identified the well screen lengths of each monitoring well or clusters? (Y/N) ___
e. Does the owner/operator provide an explanation for the well screen lengths of each monitoring well or cluster? (Y/N) ___
f. Do the actual locations of monitoring wells or clusters correspond to those identified by the owner/operator? (Y/N) ___

2. Placement of Upgradient Monitoring Wells

a. Has the owner/operator documented the location of each upgradient monitoring well or cluster? (Y/N) ___
b. Does the owner/operator provide an explanation for the location(s) of the upgradient monitoring wells? (Y/N) ___
c. What length screen has the owner/operator employed in the background monitoring well(s)?

____
____
____
____

d. Does the owner/operator provide an explanation for the screen length(s) chosen? (Y/N) ___
e. Does the actual location of each background monitoring well or cluster correspond to that identified by the owner/operator? (Y/N) ___

I. Office Evaluation of the Facility's Assessment Monitoring Program

1. Does the assessment plan specify:
   a. The number, location, and depth of wells? (Y/N) ___
   b. The rationale for their placement and identify the basis that will be used to select subsequent sampling locations and depths in later assessment phases? (Y/N) ___
2. Does the list of monitoring parameters include all hazardous waste constituents from the facility? (Y/N) ___
   a. Does the water quality parameter list include other important indicators not classified as hazardous waste constituents? (Y/N) ___
   b. Does the owner/operator provide documentation for the listed wastes which are not included? (Y/N) ___
3. Does the owner/operator's assessment plan specify the procedures to be used to determine the rate of constituent migration in the ground-water? (Y/N) ___
4. Has the owner/operator specified a schedule of implementation in the assessment plan? (Y/N) ___
5. Have the assessment monitoring objectives been clearly defined in the assessment plan? (Y/N) ___
   a. Does the plan include analysis and/or re-evaluation to determine if significant contamination has occurred in any of the detection monitoring wells? (Y/N) ___
   b. Does the plan provide for a comprehensive program of investigation to fully characterize the rate and extent of contaminant migration from the facility? (Y/N) ___
   c. Does the plan call for determining the concentrations of hazardous wastes and hazardous waste constituents in the ground water? (Y/N) ___
   d. Does the plan employ a quarterly monitoring program? (Y/N) ___
6. Does the assessment plan identify the investigatory methods that will be used in the assessment phase? (Y/N) ___
   a. Is the role of each method in the evaluation fully described? (Y/N) ___
   b. Does the plan provide sufficient descriptions of the direct methods to be used? (Y/N) ___
   c. Does the plan provide sufficient descriptions of the indirect methods to be used? (Y/N) ___
   d. Will the method contribute to the further characterization of the contaminant movement? (Y/N) ___
7. Are the investigatory techniques utilized in the assessment program based on direct methods? (Y/N) ___
   a. Does the assessment approach incorporate indirect methods to further support direct methods? (Y/N) ___
   b. Will the planned methods called for in the assessment approach ultimately meet performance standards for assessment monitoring? (Y/N) ___

c. Are the procedures well defined? (Y/N) ___
d. Does the approach provide for monitoring wells similar in design and construction as the detection monitoring wells? (Y/N) ___
e. Does the approach employ taking samples during drilling or collecting core samples for further analysis? (Y/N) ___

8. Are the indirect methods to be used based on reliable and accepted geophysical techniques? (Y/N) ___
   a. Are they capable of detecting subsurface changes resulting from contaminant migration at the site? (Y/N) ___
   b. Is the measurement at an appropriate level of sensitivity to detect ground-water quality changes at the site? (Y/N) ___
   d. Is the method appropriate considering the nature of the subsurface materials? (Y/N) ___
   e. Does the approach consider the limitations of these methods? (Y/N) ___
   f. Will the extent of contamination and constituent concentration be based on direct methods and sound engineering judgment? (Using indirect methods to further substantiate the findings) (Y/N) ___

9. Does the assessment approach incorporate any mathematical modeling to predict contaminant movement? (Y/N) ___
   a. Will site specific measurements be utilized to accurately portray the subsurface? (Y/N) ___
   b. Will the derived data be reliable? (Y/N) ___
   c. Have the assumptions been identified? (Y/N) ___
   d. Have the physical and chemical properties of the site-specific wastes and hazardous waste constituents been identified? (Y/N) ___

J. Conclusions

1. Subsurface geology

   a. Has sufficient data been collected to adequately define petrography and petrographic variation? (Y/N) ___
   b. Has the subsurface geochemistry been adequately defined? (Y/N) ___
   c. Was the boring/coring program adequate to define subsurface geologic variation? (Y/N) ___
   d. Was the owner/operator's narrative description complete and accurate in its interpretation of the data? (Y/N) ___
   e. Does the geologic assessment address or provide means to resolve any information gaps? (Y/N) ___

2. Ground-water flowpaths

a. Did the owner/operator adequately establish the horizontal and vertical components of ground-water flow? (Y/N) ___
b. Were appropriate methods used to establish ground-water flowpaths? (Y/N) ___
c. Did the owner/operator provide accurate documentation? (Y/N) ___
d. Are the potentiometric surface measurements valid? (Y/N) ___
e. Did the owner/operator adequately consider the seasonal and temporal effects on the ground-water? (Y/N) ___
f. Were sufficient hydraulic conductivity tests performed to document lateral and vertical variation in hydraulic conductivity in the entire hydrogeologic subsurface below the site? (Y/N) ___

3. Uppermost aquifer

a. Did the owner/operator adequately define the uppermost aquifer? (Y/N) ___

4. Monitoring Well Construction and Design

a. Do the design and construction of the owner/operator's ground-water monitoring wells permit depth discrete ground-water samples to be taken? (Y/N) ___
b. Are the samples representative of ground-water quality? (Y/N) ___
c. Are the ground-water monitoring wells structurally stable? (Y/N) ___
d. Does the ground-water monitoring well's design and construction permit an accurate assessment of aquifer characteristics? (Y/N) ___

5. Detection Monitoring

a. Downgradient Wells
Do the location, and screen lengths of the ground-water monitoring wells or clusters in the detection monitoring system allow the immediate detection of a release of hazardous waste or constituents from the hazardous waste management area to the uppermost aquifer? (Y/N) ___

b. Upgradient Wells
Do the location and screen lengths of the upgradient (background) ground-water monitoring wells ensure the capability of collecting ground-water samples representative of upgradient (background) ground-water quality including any ambient heterogenous chemical characteristics? (Y/N) ___

6. Assessment Monitoring

a. Has the owner/operator adequately characterized site hydrogeology to determine contaminant migration? (Y/N) ___
b. Is the detection monitoring system adequately designed and constructed to immediately detect any contaminant release? (Y/N) ___
c. Are the procedures used to make a first determination of contamination adequate? (Y/N) ___
d. Is the assessment plan adequate to detect, characterize, and track contaminant migration? (Y/N) ___
e. Will the assessment monitoring wells, given site hydrogeologic conditions, define the extent and concentration of contamination in the horizontal and vertical planes? (Y/N) ___
f. Are the assessment monitoring wells adequately designed and constructed? (Y/N) ___
g. Are the sampling and analysis procedures adequate to provide true measures of contamination? (Y/N) ___
h. Do the procedures used for evaluation of assessment monitoring data result in determinations of the rate of migration, extent of migration, and hazardous constituent composition of the contaminant plume? (Y/N) ___
i. Are the data collected at sufficient frequency and duration to adequately determine the rate of migration? (Y/N) ___
j. Is the schedule of implementation adequate? (Y/N) ___
k. Is the owner/operator's assessment monitoring plan adequate? (Y/N) ___
   o If the owner/operator had to implement his assessment monitoring plan, was it implemented satisfactorily? (Y/N) ___

II. Field Evaluation

A. Ground-water monitoring system:
Are the numbers, depths, and locations of monitoring wells in agreement with those reported in the facility's monitoring plan? (See Section 3.2.3) (Y/N) ___

B. Monitoring well construction:
1. Identify construction material

	Material	Diameter
a. Primary Casing	______	______
b. Secondary or outside casing	______	______

2. Is the upper portion of the borehole sealed with concrete to prevent infiltration from the surface? (Y/N) ___

3. Is the well fitted with an above-ground protective device? (Y/N) ___

4. Is the protective cover fitted with locks to prevent tampering? (Y/N) ___

If a facility utilizes more than a single well design, answer the above questions for each well design.

III. Review of Sample Collection Procedures

A. Measurement of well depths elevation:

1. Are measurements of both depth to standing water and depth to the bottom of the well made? (Y/N) ___

2. Are measurements taken to the 0.01 feet? (Y/N) ___

3. What device is used?

____

4. Is there a reference point established by a licensed surveyor? (Y/N) ___

5. Is the measuring equipment properly cleaned between well locations to prevent cross contamination? (Y/N) ___

B. Detection of immiscible layers:

1. Are procedures used which will detect light phase immiscible layers? (Y/N) ___

2. Are procedures used which will detect heavy phase immiscible layers? (Y/N) ___

C. Sampling of immiscible layers:

1. Are the immiscible layers sampled separately prior to well evacuation? (Y/N) ___

2. Do the procedures used minimize mixing with water soluble phases? (Y/N) ___

D. Well evacuation:

1. Are low yielding wells evacuated to dryness? (Y/N) ___

2. Are high yielding wells evacuated so that at least three casing volumes are removed? (Y/N) ___

3. What device is used to evacuate the wells?

   ____

4. If any problems are encountered (e.g., equipment malfunction) are they noted in a field logbook? (Y/N) ___

E. Sample withdrawal:

1. For low yielding wells, are samples for volatiles, pH, and oxidation/reduction potential drawn first after the well recovers? (Y/N) ___

2. Are samples withdrawn with either flurocarbon/resins or stainless steel (316, 304 or 2205) sampling devices? (Y/N) ___

3. Are sampling devices either bottom valve bailers or positive gas displacement bladder pumps? (Y/N) ___

4. If bailers are used, is fluorocarbon/resin coated wire, single strand stainless steel wire, or monofilament used to raise and lower the bailer? (Y/N) ___

5. If bladder pumps are used, are they operated in a continuous manner to prevent aeration of the sample? (Y/N) ___

6. If bailers are used, are they lowered slowly to prevent degassing of the water? (Y/N) ___

7. If bailers are used, are the contents transferred to the sample container in a way that minimizes agitation and aeration? (Y/N) ___

8. Is care taken to avoid placing clean sampling equipment on the ground or other contaminated surfaces prior to insertion into the well? (Y/N) ___

9. If dedicated sampling equipment is not used, is equipment disassembled and thoroughly cleaned between samples? (Y/N) ___

10. If samples are for inorganic analysis, does the cleaning procedure include the following sequential steps:
    a. Dilute acid rinse (HNO_3 or HCl)? (Y/N) ___

11. If samples are for organic analysis, does the cleaning procedure include the following sequential steps:
    a. Nonphosphate detergent wash? (Y/N) ___
    b. Tap water rinse? (Y/N) ___

c. Distilled/deionized water rinse? (Y/N) ___
d. Acetone rinse? (Y/N) ___
e. Pesticide-grade hexane rinse? (Y/N) ___

12. Is sampling equipment thoroughly dry before use? (Y/N) ___

13. Are equipment blanks taken to ensure that sample cross-contamination has not occurred? (Y/N) ___

14. If volatile samples are taken with a positive gas displacement bladder pump, are pumping rates below 100 ml/min? (Y/N) ___

F. In-situ or field analyses:

1. Are the following labile (chemically unstable) parameters determined in the field:
   a. pH? (Y/N) ___
   b. Temperature? (Y/N) ___
   c. Specific conductivity? (Y/N) ___
   d. Redox potential? (Y/N) ___
   e. Chlorine? (Y/N) ___
   f. Dissolved oxygen? (Y/N) ___
   g. Turbidity? (Y/N) ___
   h. Other (specify) ______________________________

2. For in-situ determinations, are they made after well evacuation and sample removal? (Y/N) ___

3. If sample is withdrawn from the well, is parameter measured from a split portion? (Y/N) ___

4. Is monitoring equipment calibrated according to manufacturers' specifications and consistent with SW-846? (Y/N) ___

5. Is the date, procedure, and maintenance for equipment calibration documented in the field logbook? (Y/N) ___

IV. Review of Sample Preservation and Handling Procedures

A. Sample containers:

1. Are samples transferred from the sampling device directly to their compatible containers? (Y/N) ___

2. Are sample containers for metals (inorganics) analyses polyethylene with polypropylene caps? (Y/N) ___

3. Are sample containers for organics analysis glass bottles with fluorocarbonresin-lined caps? (Y/N) ___

4. If glass bottles are used for metals samples are the caps fluorocarbonresin-lined? (Y/N) ___

5. Are the sample containers for metal analyses cleaned using these sequential steps?
   a. Nonphosphate detergent wash? (Y/N) ___
   b. 1:1 nitric acid rinse? (Y/N) ___
   c. Tap water rinse? (Y/N) ___
   d. 1:1 hydrochloric acid rinse? (Y/N) ___
   e. Tap water rinse? (Y/N) ___
   f. Distilled/deionized water rinse? (Y/N) ___

6. Are the sample containers for organic analyses cleaned using these sequential steps?
   a. Nonphosphate detergent/hot water wash? (Y/N) ___
   b. Tap water rinse? (Y/N) ___
   c. Distilled/deionized water rinse? (Y/N) ___
   d. Acetone rinse? (Y/N) ___
   e. Pesticide-grade hexane rinse? (Y/N) ___

7. Are trip blanks used for each sample container type to verify cleanliness? (Y/N) ___

B. Sample preservation procedures:

1. Are samples for the following analyses cooled to 4°C:
   a. TOC? (Y/N) ___
   b. TOX? (Y/N) ___
   c. Chloride? (Y/N) ___
   d. Phenols? (Y/N) ___
   e. Sulfate? (Y/N) ___
   f. Nitrate? (Y/N) ___
   g. Coliform bacteria? (Y/N) ___
   h. Cyanide? (Y/N) ___
   i. Oil and grease? (Y/N) ___
   j. Hazardous constituents (§261, Appendix VIII)? (Y/N) ___

2. Are samples for the following analyses field acidified to pH <2 with HNO_3:
   a. Iron? (Y/N) ___
   b. Manganese? (Y/N) ___
   c. Sodium? (Y/N) ___
   d. Total metals? (Y/N) ___
   e. Dissolved metals? (Y/N) ___
   f. Fluoride? (Y/N) ___
   g. Endrin? (Y/N) ___
   h. Lindane? (Y/N) ___
   i. Methoxychlor? (Y/N) ___
   j. Toxaphene? (Y/N) ___

k. 2,4, D? (Y/N) ___
l. 2,4,5, TP Silvex? (Y/N) ___
m. Radium? (Y/N) ___
n. Gross alpha? (Y/N) ___
o. Gross beta? (Y/N) ___

3. Are samples for the following analyses field acidified to pH <2 with H_2SO_4: (Y/N) ___
   a. Phenols? (Y/N) ___
   b. Oil and grease? (Y/N) ___

4. Is the sample for TOC analyses field acidified to pH <2 with HCl? (Y/N) ___

5. Is the sample for TOX analysis preserved with 1 ml of 1.1 M sodium sulfite? (Y/N) ___

6. Is the sample for cyanide analysis preserved with NaOH to pH >12? (Y/N) ___

C. Special handling considerations:
1. Are organic samples handled without filtering? (Y/N) ___

2. Are samples for volatile organics transferred to the appropriate vials to eliminate headspace over the sample? (Y/N) ___

3. Are samples for metal analysis split into two portions? (Y/N) ___

4. Is the sample for dissolved metals filtered through a 0.45 micron filter? (Y/N) ___

5. Is the second portion not filtered and analyzed for total metals? (Y/N) ___

6. Is one equipment blank prepared each day of ground-water sampling? (Y/N) ___

V. Review of Chain-of-Custody Prodecures

A. Sample labels
1. Are sample labels used? (Y/N) ___

2. Do they provide the following information:
   a. Sample identification number? (Y/N) ___
   b. Name of collector? (Y/N) ___
   c. Date and time of collection? (Y/N) ___
   d. Place of collection? (Y/N) ___
   e. Parameter(s) requested and preservatives used? (Y/N) ___

3. Do they remain legible even if wet? (Y/N) ___

B. Sample seals:

1. Are sample seals placed on those containers to ensure the samples are not altered? (Y/N) ___

C. Field logbook:

1. Is a field logbook maintained? (Y/N) ___

2. Does it document the following:

   a. Purpose of sampling (e.g., detection or assessment)? (Y/N) ___
   b. Location of well(s)? (Y/N) ___
   c. Total depth of each well? (Y/N) ___
   d. Static water level depth and measurement technique? (Y/N) ___
   e. Presence of immiscible layers and detection method? (Y/N) ___
   f. Collection method for immiscible layers and sample identification numbers? (Y/N) ___
   g. Well evacuation procedures? (Y/N) ___
   h. Sample withdrawal procedure? (Y/N) ___
   i. Date and time of collection? (Y/N) ___
   j. Well sampling sequence? (Y/N) ___
   k. Types of sample containers and sample identification number(s)? (Y/N) ___
   l. Preservative(s) used? (Y/N) ___
   m. Parameters requested? (Y/N) ___
   n. Field analysis data and method(s)? (Y/N) ___
   o. Sample distribution and transporter? (Y/N) ___
   p. Field observations? (Y/N) ___
      - o Unusual well recharge rates? (Y/N) ___
      - o Equipment malfunction(s)? (Y/N) ___
      - o Possible sample contamination? (Y/N) ___
      - o Sampling rate? (Y/N) ___

D. Chain-of-custody record:

1. Is a chain-of-custody record included with each sample? (Y/N) ___
2. Does it document the following:
   a. Sample number? (Y/N) ___
   b. Signature of collector? (Y/N) ___
   c. Date and time of collection? (Y/N) ___
   d. Sample type? (Y/N) ___
   e. Station location? (Y/N) ___
   f. Number of containers? (Y/N) ___
   g. Parameters requested? (Y/N) ___
   h. Signatures of persons involved in the chain-of-possession? (Y/N) ___ (Y/N) ___
   i. Inclusive dates of possession? (Y/N) ___

E. Sample analysis request sheet:
   1. Does a sample analysis request sheet accompany each sample? (Y/N) ___

   2. Does the request sheet document the following:
      a. Name of person receiving the sample? (Y/N) ___
      b. Date of sample receipt? (Y/N) ___
      c. Laboratory sample number (if different than field number)? (Y/N) ___
      d. Analyses to be performed? (Y/N) ___

VI. Review of Quality Assurance/Quality Control

A. Is the validity and reliability of the laboratory and field generated data ensured by a QA/QC program? (Y/N) ___

B. Does the QA/QC program include:
   1. Documentation of any deviations from approved procedures? (Y/N) ___

   2. Documentation of analytical results for:
      a. Blanks? (Y/N) ___
      b. Standards? (Y/N) ___
      c. Duplicates? (Y/N) ___
      d. Spiked samples? (Y/N) ___
      e. Detectable limits for each parameter being analyzed? (Y/N) ___

C. Are approved statistical methods used? (Y/N) ___

D. Are QC samples used to correct data? (Y/N) ___

E. Are all data critically examined to ensure it has been properly calculated and reported? (Y/N) ___

VII. Surficial Well Inspection and Field Observation

A. Are the wells adequately maintained? (Y/N) ___

B. Are the monitoring wells protected and secure? (Y/N) ___

C. Do the wells have surveyed casing elevations? (Y/N) ___

D. Are the ground-water samples turbid? (Y/N) ___

E. Have all physical characteristics of the site been noted in the inspector's field notes (i.e., surface waters, topography, surface features)? (Y/N) ___

F. Has a site sketch been prepared by the field inspector with a scale, north arrow, location(s) of buildings, location(s) of regulated units, location of monitoring wells, and a rough depiction of the site drainage pattern? (Y/N) ___

VIII. Conclusions

A. Is the facility currently operating under the correct monitoring program according to the statistical analyses performed by the current operator? (Y/N) ___

B. Does the ground-water monitoring system, as designed and operated, allow for detection or assessment of any possible ground-water contamination caused by the facility? (Y/N) ___

C. Does the sampling and analysis procedures permit the owner/operator to detect and, where possible, assess the nature and extent of a release of hazardous constituents to ground water from the monitored hazardous waste management facility? (Y/N) ___

FIGURE 4.3

RELATIONSHIP OF TECHNICAL INADEQUACIES TO GROUND-WATER PERFORMANCE STANDARDS

Examples of Basic Elements Required by Performance Standards	Examples of Technical Inadequacies that may Constitute Violations	Regulatory Citations
1. Uppermost Aquifer must be correctly identified	• failure to consider aquifers hydraulically interconnected to the uppermost aquifer	§265.90(a) §265.91(a)(1) (a)(2) §270.14(c)(2)
	• incorrect identification of certain formations as confining layers or aquitards	§265.90(a) §265.91(a)(1) (a)(2) §270.14(c)(2)
	• failure to use test drilling and/or soil borings to characterize subsurface hydrogeology	§265.90(a) §265.91(a)(1) (a)(2) §270.14(c)(2)
2. Ground-water flow directions and rates must be properly determined	• failure to use piezometers or wells to determine ground-water flow rates and directions (or failure to use a sufficient number of them)	§265.90(a) §265.91(a)(1) (a)(2) §270.14(c)(2)
	• failure to consider temporal variations in water levels when establishing flow directions (e.g., seasonal variations, short-term fluctuations due to pumping)	§290.90(a) §295.91(a)(1) (a)(2) §270.14(c)(2)
	• failure to assess significance of vertical gradients when evaluating flow rates and directions.	§265.90(a) §295.91(a)(1) (a)(2) §270.14(c)(2)
	• failure to use standard/consistent benchmarks when establishing water level elevations	§265.90(a) §265.91(a)(1) (a)(2) §270.14(c)(2)
	• failure of the O/O to consider the effect of local withdrawal wells on ground-water flow direction	§265.90(a) §265.91(a)(1)
	• failure of the O/O to obtain sufficient water level measurements	§265.90(a) §265.91(a)(1)

Examples of Basic Elements Required by Performance Standards	Examples of Technical Inadequacies that may Constitute Violations	Regulatory Citations
3. Background wells must be located so as to yield samples that are not affected by the facility	• failure of the O/O to consider the effect of local withdrawal wells on ground-water flow direction	§265.90(a) §265.91(a)(1)
	• failure of the O/O to obtain sufficient water level measurements	§265.90(a) §265.91(a)(1)
	• failure of the O/O to consider flow path of dense immiscibles in establishing upgradient well locations	§265.90(a) §265.91(a)(1)
	• failure of the O/O to consider seasonal fluctuations in ground-water flow direction	§265.90(a) §265.91(a)(1)
	• failure to install wells hydraulically upgradient, except in cases where upgradient water quality is affected by the facility (e.g., migration of dense immiscibles in the upgradient direction, mounding of water beneath the facility)	§265.90(a) §265.91(a)(1)
	• failure of the O/O to adequately characterize subsurface hydrogeology	§265.90(a) §265.91(a)(1)
	• wells intersect only ground water that flows around facility	§265.90(a) §265.91(a)(1)
4. Background wells must be constructed so as to yield samples that are representative of in-situ ground-water quality	• wells constructed of materials that may release or sorb constituents of concern	§265.90(a) §265.91(a)
	• wells improperly sealed—contamination of sample is a concern	§265.90(a) §265.91(a) §265.91(c)
	• nested or mulitple screen wells are used and it cannot be demonstrated that there has been no movement of ground water between strata	§265.90(a) §265.91(a)(1) §265.91(a)(2)
	• improper drilling methods were used, possibly contaminating the formation	§265.90(a) §265.91(a)
	• well intake packed with materials that may contaminate sample	§265.90(a) §265.91(a) §265.91(c)

Examples of Basic Elements Required by Performance Standards	Examples of Technical Inadequacies that may Constitute Violations	Regulatory Citations
Background wells must be constructed so as to yield samples that are representative of in-situ ground-water quality. (continued)	• well screens used are of an inappropriate length	§265.90(a) §265.91(a)(1) §265.91(a)(2)
	• wells developed using water other than formation water	§265.90(a) §265.91(a)
	• improper well development yielding samples with suspended sediments that may bias chemical analysis	§265.90(a) §265.91(a)
	• use of drilling muds or nonformation water during well construction that can bias results of samples collected from wells	§265.90(a) §265.91(a)
5. Downgradient monitoring wells must be located so as to ensure the immediate detection of any contamination migrating from the facility	• wells not placed immediately adjacent to waste management area	§265.90(a) §265.91(a)(2)
	• failure of O/O to consider potential pathways for dense immiscibles	§265.90(a) §265.91(a)(2)
	• inadequate vertical distribution of wells in thick or heavily stratified aquifer	§265.90(a) §265.91(a)(2)
	• inadequate horizontal distribution of wells in aquifers of varying hydraulic conductivity	§265.90(a) §265.91(a)(2)
	• likely pathways of contamination (e.g., buried stream channels, fractures, areas of high permeability) are not intersected by wells	§265.90(a) §265.91(a)(2)
	• well network covers uppermost but not interconnected aquifers	§265.90(a) §265.91(a)(2)
6. Downgradient monitoring wells must be constructed so as to yield samples that are representative of in-situ ground-water quality	See #4	

Examples of Basic Elements Required by Performance Standards	Examples of Technical Inadequacies that may Constitute Violations	Regulatory Citations
7. Samples from background and down-gradient wells must be properly collected and analyzed	• failure to evacuate stagnant water from the well before sampling	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• failure to sample wells within a reasonable amount of time after well evacuation	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• improper decisions regarding filtering or non-filtering of samples prior to analysis (e.g., use of filtration on samples to be analyzed for volatile organics)	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• use of an inappropriate sampling device	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• use of improper sample preservation techniques	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• samples collected with a device that is constructed of materials that interfere with sample integrity	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• samples collected with a non-dedicated sampling device that is not cleaned between sampling events	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• improper use of a sampling device such that sample quality is affected (e.g., degassing of sample caused by agitation of bailer)	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)

FIGURE 4.3 (continued)

Examples of Basic Elements Required by Performance Standards	Examples of Technical Inadequacies that may Constitute Violations	Regulatory Citations
Samples from background and downgradient wells must be properly collected and analyzed (continued)	• improper handling of samples (e.g., failure to eliminate headspace from containers of samples to be analyzed for volatiles)	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• failure of the sampling plan to establish procedures for sampling immiscibles (i.e., "floaters" and "sinkers")	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• failure to follow appropriate QA/QC procedures	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• failure to ensure sample integrity through the use of proper chain-of-custody procedures	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• failure to demonstrate suitability of methods used for sample analysis (other than those specified in SW-846)	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• failure to perform analysis in the field on unstable parameters or constituents (e.g., pH, Eh, specific conductance, alkalinity, dissolved oxygen)	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• use of sample containers that may interfere with sample quality (e.g., synthetic containers used with volatile samples)	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)
	• failure to make proper use of sample blanks	§265.90(a) §265.92(a) §265.93(d)(4) §270.14(c)(4)

Examples of Basic Elements Required by Performance Standards	Examples of Technical Inadequacies that may Constitute Violations	Regulatory Citations
8. In Part 265 assessment monitoring the O/O must sample for the correct substances	• failure of the O/O's list of sampling parameters to include certain wastes that are listed in §261.24 or §261.33, unless adequate justification is provided	§265.93(d)(4)
	• failure of the O/O's list of sampling parameters to include Appendix VII constituents of all wastes listed under §§261.31 and 261.32, unless adequate justification is provided	§265.93(d)(4)
9. In defining the Appendix VIII makeup of a plume the O/O must sample for the correct substances	• failure of the O/O's list of sampling parameters to include all Appendix VIII constituents, unless adequate justification is provided	§270.14(c)(4)
10. In Part 265 assessment monitoring and in defining the Appendix VIII makeup of a plume the O/O must use appropriate sampling methodologies	• failure of sampling effort to identify areas outside the plume	§265.93(d)(4) §270.14(c)(4)
	• number of wells was insufficient to determine vertical and horizontal gradients in contaminant concentrations	§265.93(d)(4) §270.14(c)(4)
	• total reliance on indirect methods to characterize plume (e.g., electrical resistivity, borehole geophysics)	§265.93(d)(4) §270.14(c)(4)
11. Part B applicants who have either detected contamination or failed to implement an adequate part 265 GWM program must determine with confidence whether a plume exists and must characterize any plume	• failure of O/O to implement a monitoring program that is capable of detecting the existence of any plume that might emanate from the facility	§270.14(c)(4)
	• failure of O/O to sample both upgradient and downgradient wells for all Appendix VIII constituents	§270.14(c)(4)
	See also items #1, #2	